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Proposing an Evaluation Framework for Energy Policy Making Incorporating Equity: Applications in Australia.

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Abstract

The sustainability of energy policy performance is determined by a combination of environmental, economic and equity impacts on society. To date, analysis of the equity impacts of energy policy have been largely overlooked in favour of environmental and economic impacts. As equity is an important issue within sustainability and energy justice considerations, this paper sets out to provide a framework and methodology which allows an assessment of both policy effectiveness in terms of an environmental and economic evaluation, followed up by an assessment of resultant quantitative equity impacts on society, in order to engender a holistic policy sustainability evaluation. Following an investigation of prominent energy policy equity issues and Australian peoples preferences towards equity, multiple scenarios are evaluated for effectiveness within the Australian National Electricity Market. The results of this evaluation provide an evidence base for the development of an alternative energy scenario which addresses the identified equity issues whilst meeting policy goals. The equity evaluation demonstrates the comparative equity resultant from each scenario and identifies the apportioning of burden according to income level. The proposed evaluation processes allow the policy maker to develop policies sensitive to both effectiveness and equity, and can be applied in energy justice conscious jurisdictions.

Keywords: equity, energy policy, sustainability, distributive justice.

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1. Introduction

This research is concerned first and foremost with the sustainability of energy policy. Sustainability is elegantly described by Campbell (1996) as a conflict between economic development, environmental protection and equity and social justice. It is further suggested that a balance of these three factors defines sustainability (Wheeler, 2002). This research contends firstly, that each factor is critically important in the development of sustainable energy policy and, secondly, that social equity factors have been largely overlooked in renewable energy (RE) system and policy analysis to date.

"Sustainability of policy performance" in this research is defined as the degree to which policy can meet environmental and economic goals, without impairing societal equity. This definition is synonymous with the ideals of sustainability being a subset of economic, social and environmental factors. By incorporating equity alongside economic and environmental factors into policy efficacy (the ability of a policy to meet desired goals) and sustainability assessments, it is proposed that the impact of energy policy implementation on equity outcomes and overall sustainability performance can be determined.

The unique factor which will be applied to energy policy assessment in this study is equity, primarily concerned with the distribution of environmental and economic costs and benefits of a policy's implementation on society. For the purposes of this research, which considers the short-term impacts of policy decisions, equity issues are identified specific to the investigated jurisdiction and measured intra-generationally, focusing on the present policy scenario and projected outcomes to 2020 (a five-year period at the time of writing). In order to effect equal treatment across income levels within the examined jurisdiction in line with the distributional justice approach taken in this study (concerned with the distribution of the benefits and ills of energy policy outcomes across societal income levels), vertical equity is applied, so as to enforce a user-pays system, fair value of subsidisations and payments to participants, and to limit the burden on non-participants in subsidisation schemes; to improve equity between low and high income households.

In harmony with the ideal of maintaining balance between economy, environment and equity in order to determine holistic sustainability, each of these three key factors will be considered concurrently.

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This paper builds on a review and analysis by the author of small scale RE policies which supported residential solar photovoltaic (PV) installation in Australia between 2001 and 2012 (Chapman et al, 2016). The proposed assessment framework methodology will utilize the economic and environmental outcomes of this research to measure both the sustainability and efficacy of energy policies, in addition to defining the role and quantification method of equity within these evaluations.

This paper uses the OECD nation of Australia as its case study in which the main stimulatory measures used to encourage RE deployment under the Renewable Energy Target (RET) are Renewable Energy Certificates (REC) and Feed-in tariffs (FiT). Many other OECD nations also use these stimulatory policy approaches and share common factors with regard to government structure. These commonalities suggest that the policy sustainability assessment framework proposed in this paper could be readily applied more broadly in nations that are concerned with injustices in energy and environmental matters.

The aim of this paper is to establish equity as a key consideration for energy policy development in order to provide a basis for the improvement of the future energy policy development process, with the aim of strong energy, environment and economic outcomes whilst decreasing inequity between societal income levels.

The key research themes relevant to the energy studies and social science field which are addressed in this paper are: 1) The appropriate distribution of the costs and benefits of energy production and its use; 2) Fairness issues for present generations due to disproportionate access to the benefits of, and disproportionate sharing of the burdens of energy; and, 3) A consideration of the energy technologies which may exacerbate inequality and concentrate wealth (adapted from Sovacool, 2014).

2. Sustainability of Policy Evaluation and Equity in Energy Policy

To date, many scholars have assessed RE policies and technologies considering economic and environmental measures to determine their efficacy and contribution to sustainability outcomes. For example, Liu et al (2013, 2014) propose a general sustainability indicator of RE systems, using Grey Relational Analysis and a triple bottom line approach. Whilst this work cites and recognizes the importance of the environmental, economic and social dimensions of sustainability in an energy system,

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the prioritization process gives precedence to environmental and economic factors, which both contain numerous (positive and negative) indicators. Social sustainability factors analysed include only two factors (both positive): the number of households benefited and new job numbers. In addition, these social factors are weighted overall at 0.0056 (less than 1%) of the overall sustainability index causing their impact to be insignificant on the final result.

Dombi et al (2014) also propose a method to assess the sustainability of renewable power and heat generation technologies using a multi criteria analysis and choice experiment to establish a priority for the technologies assessed. The use of qualitative measures across environmental, economic and social factors is laudable, however in this case study, social factors considered only include new jobs and local income, suggesting that social attributes of sustainability are only positive, do not contain equity measures, and are easily contrasted across scenarios. Although the joint use of techniques such as multi criteria analysis and choice experiment methods to determine systemic sustainability is well supported (Roche et al, 2010, Beria et al 2012), it should also be recognized that multi criteria analysis such as the Analytical Hierarchy Process (AHP) (Saaty, 1977) is said to produce the best results when a diverse range of stakeholders are engaged (Yavuz and Baycan, 2013, Delgado-Galvan et al, 2014). In Dombi et al.'s study, 172 Hungarian professionals associated with ecological economics or environmental policy were selected for the choice experiment to rank RE system scenarios. This selection method does not represent a diverse group of stakeholders, and therefore outcomes of sustainability priorities are skewed according to a single group's point of view.

Evans et al (2009) in their assessment of sustainability indicators for RE technologies propose that sustainability is equally influenced by environmental, economic and social impact indicators, and economic and environmental factors evaluated utilize quantitative, well referenced data. Social impacts, however are relatively arbitrary and represent only one seventh of the total sustainability score. The sub factors of social impact are qualitative, covering aspects of: amenity (noise, visual and odour), toxins, seismic activity, river damage, displacement, pollution and agricultural impact, all measured on a scale of minor to major. It could be argued that some of these sub factors are actually environmental concerns, and none of them are representative of equity. The technologies of wind, hydro, geothermal and solar PV are compared and ranked across seven factors of: price, emissions, limitations, efficiency, land use, water consumption and the combined factors grouped as social impacts. Notwithstanding the limitations of the methodology proposed, the results are not significantly influenced by social factors

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in the overall appraisal of sustainability across RE technologies.

The recent academic literature reviewed above is a representative selection of energy policy and technology sustainability assessment approaches. The literature review suggests that sustainability is predominantly assessed based on economic and environmental factors, with social factors, especially equity overlooked or undervalued. It is contended that the assessment of energy policy and technological approaches from the literature review represent a measurement of efficacy – the ability of an energy policy to achieve its economic and environmental goals, and efficiency – to achieve these goals at the best cost.

Although many authors use similar terms including sustainability, social impacts and equity, these words are often used inconsistently and conceptual confusion abounds (Ikeme, 2003). Whilst there is general agreement that sustainability consists of interdependent economic, environmental and social factors (IAEA, 2005, UN, 2005, Wheeler, 2002, Campbell, 1996) - equity (a key social consideration of sustainability) is the least understood, and given the least amount of attention (Tol, 2001). This may be for a number of reasons, not least of which is that terms associated with equity, such as 'fairness' are too vague to be agreed upon by all stakeholders (Been, 1993). An examination of energy justice as a concept is helpful at this point in order to clarify the concept of equity within energy policy and to highlight the focus of this study.

Following on from the environmental and climate justice movements, energy justice has emerged as a concept which isolates energy issues from the wider range of topics examined within environmental and climate justice (Fuller and McCauley, 2016). Energy justice is concerned with the three tenets of distributive justice, justice as recognition and procedural justice. Distributive justice, which is the main theme of this study (due to identified Australian equity preferences, described in detail in section 3.2) is concerned with the distribution of benefits and ills, or burdens of energy projects and policy across society – including resources, wealth, pollution and poverty (Heffron et al, 2015, Sovacool and Dworkin, 2015). The study investigates equity issues associated with the energy system, along with the economic and environmental conditions which engender them (Sovacool and Dworkin, 2014). Justice as recognition is concerned with the recognition of social, cultural, ethnic, racial and gender differences and to ensure that none of these groups are misrepresented, disrespected, degraded or devalued in comparison to others (Heffron et al, 2015, Jenkins et al, 2016). Section 3.2 of this study

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identifies some justice as recognition issues in Australia which require redress as part of an overall assessment of equity preferences, however the assessment tool only goes as far as the recognition of different income levels and home ownership impacts. Finally, procedural justice is concerned with the meaningful engagement of all stakeholders and communities and the provision of unfettered access to government and industry information, in order to affect the policy decision making process (Heffron et al, 2015, Jenkins et al, 2016). Although procedural justice is touched on in this study, it is a topic for future research, specific to the improvement of the policy making process, rather than the evaluation of energy policies directly; recognizing that there is no single technical fix to the problems of energy injustice and that remedy must be sought through a combined social, political, economic and material approach (Bickerstaff et al, 2013).

As stated in the introduction, this study is focused on one of the central energy justice principles, intra-generational equity, specifically considering the distribution of benefits and burdens as a result of differing energy policies, who benefits from this distribution, and how costs and burdens should be distributed (Sovacool and Dworkin, 2015).

Equity is an important consideration within sustainability evaluation, often overlooked or considered inferior to economic or environmental concerns, as evidenced by the review of current approaches to assessment of energy policy and energy technology sustainability. An insufficient consideration of equity can lead to inequitable outcomes within society, and a measurable gap between the efficacy and overall sustainability of policies. By incorporating equity considerations into the policy evaluation process, more equitable policy can be developed. By improving economic, environmental and equity outcomes in a complementary manner, it follows that policy sustainability will also be positively impacted.

3. Establishing an Equitable Energy Policy Sustainability Assessment Framework

3.1 Renewable Energy Policy Equity Findings

To demonstrate the development of an assessment methodology for the sustainability of policy performance incorporating equity, Australia was chosen, as it is a country with high greenhouse gas emissions per capita, thus requiring a shift to RE generation sources. Data is readily available with regard to RE deployment and is supported by the authors' previous analysis of Australian residential RE policy from 2001-2012, which investigated economic and environmental impacts resultant from newly installed solar

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PV across this period (Chapman et al, 2016). These impacts are discussed below.

With regard to economic factors, employment was explored including the number and types of jobs created in Australia, and the development of RE associated industries as a result of RE policies. A comparison to European solar PV component manufacturing nations is also included. The outcomes of this work links directly with the job multipliers used in this study's' framework and are reflected as the GDP impacts of the policy. Income and FiT impacts on pricing were explored considering the FiT approaches (gross or net) in each of the states and how RE installing households receive FiT payments according to electricity export and usage patterns. These FiT payments are recouped by electricity distributors and added to electricity bills – meaning a benefit for one group and a burden imposed upon another. This factor is incorporated into the framework as subsidy allocations and the impact on electricity prices. Learning curves were explored for the two RE technologies being rapidly deployed in Australia, wind and PV. These learning curves are reflective of the price reduction per watt installed as deployment increases, recognizing that these prices are influenced heavily by exogenous factors as Australia has a very small RE manufacturing capacity. Learning curves are summarised as market impacts in the proposed framework.

From an environmental perspective, three key factors were considered: the CO_2 reduction capacity of the three major RE technologies in the Australian market, Hydro, wind and PV. The CO_2 reduction capacity of each technology is dependent on the generation efficiency of each technology according to Australian conditions and allows the fossil fuel offset capacity of each technology to be derived. The proposed framework expands this analysis to incorporate fossil fuel CO_2 emissions and their generation efficiency, and the CO_2 reduction and fossil fuel offset capacity of other CO_2 reducing technologies currently deployed in the Australian market (predominantly bio-fuel and gas). Table 1 summarizes the economic and environmental impacts previously explored.

Table 1. Previously Investigated Australian RE Policy Impacts (Chapman et al, 2016)

Economic Impacts	Environmental Impacts
• Employment • Income • FiT impact on pricing • Learning Curves	• CO_2 reduction per technology • Generation efficiency per technology • Offset of Fossil Fuel

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Additionally, Australia differentiates policy by state with regards to RE, as well as an overall national policy. Each state has defined their own FiT levels since 2008 as well as the payment approach (net or gross), whilst the federal government administers the REC scheme for both large and small scale generators. FiTs pay RE generators for each kilowatt hour (kWh) of electricity exported to the grid, whilst RECs are issued and traded for cash (usually at the time of purchase, in the form of a discount for household level RE) for each megawatt hour (MWh) that the system will generate. These certificates are then purchased by energy retailers in order to meet their RE obligations under the RET.

The equity impacts which have been observed post-implementation of RE policies within Australia will provide guidance for key equity factors to be incorporated into the proposed framework and are discussed below.

The equity issue most prominently identified in Australia was an increase in electricity prices due to subsidization. The authors' previous analysis highlights in detail how a review of the New South Wales State Government RE policies by the Independent Pricing and Regulatory Tribunal (IPART) showed that subsidies such as the FiT can cause greater than expected installations and drive up retail electricity prices (IPART, 2012). Further, the Queensland Competition Authority (QCA), in their consideration of a fair and reasonable FiT for Queensland - the state with the greatest number of residential PV installations - showed that current RE policies drove up costs for all consumers due to generous FiT levels and the need for network augmentation in order to accept significant deployment of residential PV (QCA, 2013). In addition to independent third party reviews of the two states with the highest levels of subsidized RE, the Federal Government also intervened to reduce favourable National subsidization schemes (REC multipliers) 6 months ahead of schedule, to reduce the impact of the high uptake of PV on electricity costs for homes and businesses and to ease pressure on electricity prices (Ministerial Media Release, Minister for Climate Change and Energy Efficiency, Minister for Industry and Innovation, 15 Nov 2012).

It is reasonable to assume that for any group of consumers, in this case home owners who could afford to install PV, to enjoy a benefit such as electricity prices below the cost of their consumption, that the remainder of consumers must pay for this benefit (whilst recognizing that there is an upfront investment by this group of consumers). Third party analysis and Ministerial statements by those ultimately responsible for RE policy

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implementation recognized that those who can least afford to participate in subsidization schemes are likely subsidizing users who receive a benefit, identifying both inequitable participation and allocation of subsidies (Commonwealth of Australia, 2011, Ministerial Media Release, Minister for Energy and Water Supply, QLD, 26 June 2012, QCA, 2013).

It has been identified that the type and method of implementation of subsidies can have a marked effect on the technologies deployed, and therefore the environmental efficacy (ability to generate renewable energy based electricity and reduce greenhouse gases) and public benefit of RE policy. In Australia, there is evidence that the FiT led to a very high cost of greenhouse gas abatement (Macintosh and Wilkinson, 2011) through specific support for less environmentally effective small-scale RE and non-generating technologies (such as solar hot water systems), and that Federal REC policies caused a stockpiling of certificates which stalled or deferred investment in large scale generation (Simpson and Clifton, 2014). Federal analysis of FiTs suggests that they are only likely to be effective in stimulating solar and wind based RE (Commonwealth of Australia, 2011).

Another factor which has been noted as having an influence upon societal equity in Australia is employment, both in the number and type of jobs provided but also through the provision of stable employment. With regard to RE policy in Australia, the previously noted changing of federal incentives and reducing state based FiTs due to excessive price impacts has had the effect of drastically reducing the RE workforce (Ecogeneration, 2011, IPART, 2012). A consideration of the flow on effects of this reduction in primarily sales and installation jobs in Queensland showed that whilst 75% of installers may be able to easily transfer to equivalent jobs in other industries, only 25% of wholesale and retail positions were likely to be re-employed elsewhere (Intelligent Energy Systems, 2012). In order to allow more households to install Solar PV and to sustain employment in the RE industry, State Governments are assessing alternative approaches to the deployment of RE which does not require a FiT, such as the retailer-household solar PV purchase agreements proposed in Victoria (Minister for Industry, Minister for Energy and Resources, VIC, 2015).

Summarizing these findings from Government and independent third party analyses, the key equity impacts considered important with regard to RE policy outcomes in Australia are: electricity price impacts (the increase of electricity bills due to FiT costs),

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participation (the ability for households to participate in subsidisation schemes, in the case of the FiT meaning home ownership and the means to purchase solar panels), subsidization allocation (identifying those households who are receiving subsidisation, and those who are burdened with the costs), environmental benefits (reduction of generation based GHG emissions through the deployment of RE) and impacts on employment (the number, type and allocation of jobs).

3.2 Australian Equity Preferences

In order to assess an approximation of the 'Australian' preference towards social equity, within the current RE regime, a number of sources were investigated, including survey results, workshop outcomes and case studies across desirable future environmental scenarios, equity and climate change investigations, water allocations and health and social justice viewpoints. Although a targeted survey may provide a more tailored response, the assessment undertaken provides an approximate initial 'desirable equity state', sufficient for the purposes of this research paper and development of the assessment methodology.

Although the concept of a 'fair go' (a phrase meaning that everyone should be given the best chance or opportunity without being unfairly hindered) has been a part of Australian culture for a long time (Herscovitch, 2013), Australia is at the high end of income inequality (OECD, 2016), and the gap between the richest and poorest 20% is similar to that of the UK, USA, Singapore and New Zealand (Wilkinson and Pickett, 2010). Specific examples of social inclusion inequality issues which arise in Australia include: place-based disadvantage with regard to access, health care and employment, private schools, women's wage equality and indigenous health and housing (UNSW, 2011). With regard to climate change, respondents to a survey stated that government policy should create fairness and balance in society, based on their belief that climate change affects low income groups the most (McManus et al, 2014). When asked to describe an ideal future for Australia, workgroup respondents across multiple locations identified many common factors including access to good education, participatory democracy, freedom, work-life balance, a healthy environment with climate change contained, sustainable industries and equitable access to services and resources. All respondents identified a preference for social equity (specifically full employment and wealth distribution) and preservation of the natural environment over economic growth (Boschetti et al, 2015). When assessing intergenerational distribution preferences, respondents understood that those who benefit from the implementation of a policy are

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unlikely to be the same people who are paying for them. Whilst a small portion (approximately 12 percent) of respondents chose the preservation of the societal status quo, the majority chose to favour younger, or future generations, even when 'non-trivial' amounts of money were involved. They reasoned that any investment would help the younger generation and their willingness to invest was based on the consideration of perceived impacts which would affect future generations negatively (Scarborough and Bennett, 2008). This future-oriented conservation focus was reinforced in a survey of acceptable risk and social values of water allocations which again identified strong support for intergenerational equity, and a preference for evidence based policies and plans managed for the public good (Syme, 2014). In addition, when health care decision makers were surveyed on desirable allocation of health gains a majority favoured the young, those of poor health and, where preference was specified, those of a lower socio economic status (Mooney and Jan, 1997). It should be noted that in some cases these preferences are assessed prior to implementation of policies and may be representative of respondent's desires rather than an approximation of their actual actions.

An examination of the Australian equity preference has shown that Australians predominantly desire that costs associated with policies (including climate change, environmental, water allocation, health and social justice policies) which include subsidisation should be borne by higher income households, whilst participation should be mostly equal, the allocation of subsidies, environmental improvements and employment benefits should be distributed with a bias toward lower income households, and an appropriate level of burden sharing according to household means.

3.3 Proposed Energy Policy Sustainability Framework

Following an assessment of previous research, and taking into account the Australian equity impact findings and preference towards impact distribution, Table 2 outlines the factors which will be evaluated by the Energy Policy Sustainability Framework proposed by this research in order to effectively measure the economic, environmental and equity impacts of energy policies within Australia.

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Table 2. Energy Policy Sustainability Performance Evaluation Framework Factors

Environmental	Economic	Social Equity
		The distribution of economic and environmental costs and benefits across income levels:
· GHG emissions (CO_2-e)	· Levelised cost of electricity (LCOE)	· Distribution of costs ➢ Electricity price increases ➢ Allocation of subsidies
· RE deployment	· Impact of subsidisation on electricity price	· Distribution of benefits ➢ Employment ➢ CO_2 reduction ➢ Participation
· RE Technology system efficiency	· GDP impacts	
	· Market impacts	

In order to demonstrate the framework's application, and to provide contrast with frameworks that do not quantify societal equity factors as part of sustainability assessment, the identified environmental and economic factors which impact upon jurisdictional equity will be evaluated, and used alongside projected energy system data to derive efficacy and societal equity impacts, in order to determine overall energy policy sustainability. Figure 1 outlines the steps undertaken in the framework for the given jurisdiction. The specific sections of this paper which detail each step are also noted.

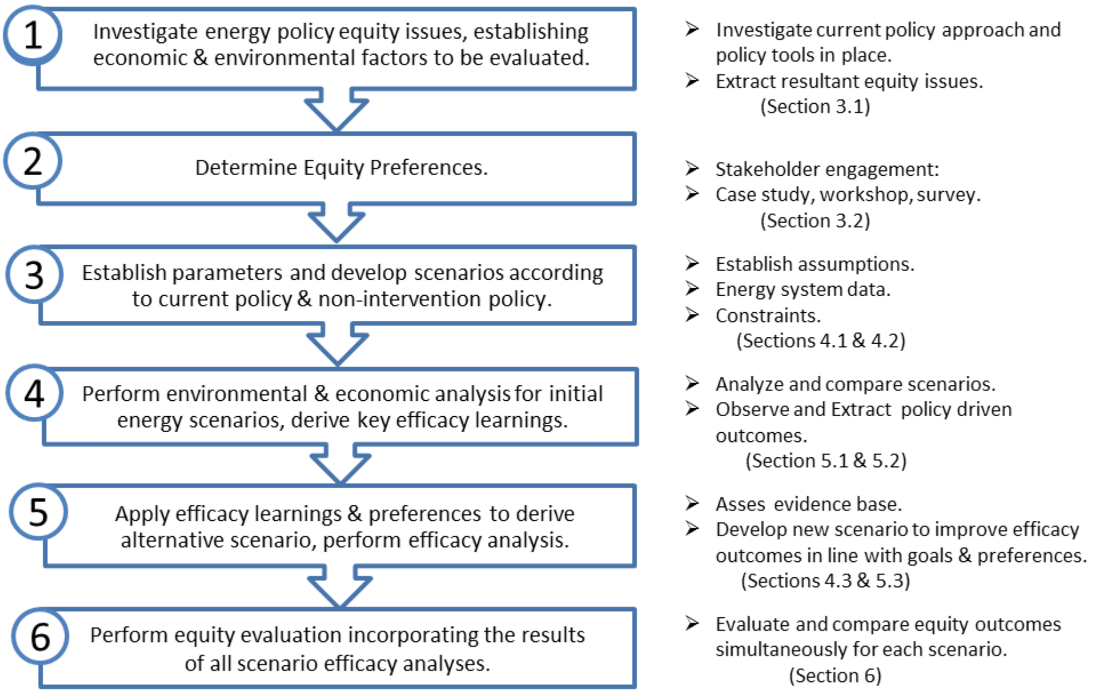

Figure 1. Energy Policy Sustainability Framework

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The framework incorporates the identified factors across the three critical elements of sustainability into the assessment process and allows the policy maker to use energy system, environmental and economic data to quantitatively derive the equity impacts upon each income level within a society. This is achieved through multiple scenario analysis considering varying policy approaches, specifically outlined in the methodology, enabling a holistic assessment of the sustainability of each energy policy scenario from the point of view of both efficacy and equity outcomes.

4. Methodology

The proposed methodology to evaluate the economic and environmental factors of energy policy sustainability is in three parts; firstly, a baseline case is established prior to the introduction of the residential solar PV FiT policy in order to develop a scenario representative of the 'preserving the status quo' policy option. Secondly, the FiT scenario is analysed to measure the changes in environmental and economic impacts when compared to the baseline scenario. Finally, utilising the outcomes identified from the FiT and baseline scenario analyses as an evidence base, an alternative energy scenario is developed in order to meet both the economic and environmental policy goals in Australia, and to do so in a manner which can at least preserve, and preferably improve societal equity outcomes.

Each of the scenarios' efficacy will be measured against the above defined Energy Policy Sustainability Framework and stated Australian Government energy and environmental goals to 2020, namely the RET which aims to ensure that 20% of Australia's electricity comes from renewable sources by 2020, with 41,000GWh of electricity to come from large-scale RE (Department of the Environment, 2015). The data used to measure all energy consumption and production factors, technology specific emission and capacity factors and additional environmental and economic factors are derived from Australian national energy reporting bodies (e.g. AER, AEMO), industry peak, research and regulatory bodies (e.g. Clean Energy Council, Green Energy Markets, IPART) and recent peer reviewed academic research. Common formulae, assumptions and methodologies for calculating each component within the environmental and economic factors for each scenario are outlined below.

Environmental:

1. GHG emissions: $Generation\,Type_{(1\ldots8)} \times tCO_{2-e} \,/\, GWh_{(1\ldots8)}$
2. RE deployment: $\sum GWh_{(RE\ Generation)} / \sum GWh_{(Fossil\ Fuel\ Based\ Generation)}$

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3. RE technology system efficiency: $Installed\ RE\ Efficiency_{(Generation,GHG)}\ /\ Maximum\ RE\ Efficiency_{(Generation,GHG)}$

Economic:

1. Cost of Generation: $LCOE_{Generation\ Mix\ (Target\ Year)}$
2. Electricity Price Impact: $FiT\ Payments_{(Year\ 1\ldots13)} / Non\ FiT\ Households_{(Year\ 1\ldots13)}$
3. GDP Impact: *New jobs arising from RE deployment (Target Year)*
4. Market Impact: *Energy generation technology learning curve price/W_p*

Where: $tCO_{2\text{-}e}$ = Tonnes of CO_2 equivalent, GHG = Greenhouse gas, LCOE = Levelised cost of electricity, (1…8) = Generation sources within the National Electricity Market (NEM) as defined in the assumptions below.

Social equity impacts are subsequently measured by evaluating the distribution of the above environmental and economic factors across the five income levels of society, (defined for Australia in Appendix C) as detailed in section 6.

Assumptions common to all scenarios:

1. The GHG intensity factors[2] of each power generation technology type is assumed to be constant over time (Fossil and Bio Fuels - AEMO, 2014; Farine et al, 2012; Solar - Fthenakis and Kim, 2011; Hydro - Varun and Prakash, 2009; Wind - Geuzuraga et al, 2012), as follows:
    1. Black Coal: 0.87 $tCO_{2\text{-}e}$/MWh
    2. Brown Coal: 1.25 $tCO_{2\text{-}e}$/MWh
    3. Gas: 0.46 $tCO_{2\text{-}e}$/MWh
    4. Liquid Fuels: 0.92 $tCO_{2\text{-}e}$/MWh
    5. Bio-Fuel[3]: 0.024 $tCO_{2\text{-}e}$/MWh
    6. Hydropower[4]: 0.0087 $tCO_{2\text{-}e}$/MWh
    7. Wind[5]: 0.0093 $tCO_{2\text{-}e}$/MWh
    8. Solar[6]: 0.036 $tCO_{2\text{-}e}$/MWh

[2] RE technology GHG intensity factors do not include GHG emissions from transportation.
[3] Lignocellulose to electricity (combustion).
[4] Run-of river system average life-cycle GHG emissions.
[5] Onshore wind turbines.
[6] Average life-cycle GHG emissions of the three dominant panel technology types; Mono-Silicon, Poly-Silicon and Cadmium-Telluride.

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2. Electricity consumption will reduce by 0.5% per annum from 2015 (based on 5-year average consumption trends; AER, 2009-2014, Green Energy Markets, 2014) due to energy efficiency improvements and reduction of energy intensive industry, leading to the retirement of fossil fuel generators.
3. Generation from Hydroelectric sources within the NEM will remain stable at historical average levels, ignoring impacts such as drought or high rainfall years, (Green Energy Markets, 2014) and no further installation will occur before 2020 (Elliston et al, 2013).
4. Liquid fuels' contribution to NEM generation will be locked at 0.01% of the total generation in each year, reflecting the approximate annual contribution to date.
5. Biofuels' growth is forecast using 2008-13 data, Gas' using 2008-14 data, both projected forward based on recent average yearly installation to 2020.
6. It is assumed that each GWh generated from renewable sources will offset a GWh of fossil fuel generation. This offset will be divided across black and brown coal, dependent on the type and location of the installed RE (e.g. Black Coal for solar PV and Bioenergy installation – predominantly installed in Queensland and NSW, and Brown Coal for Wind, predominantly installed in South Australia and Victoria. AER, 2014). Reduction in annual electricity generation, and increases in Gas generation are reduced across Brown and Black Coal generation according to their market share and location within the NEM.

4.1 Baseline Scenario

FiTs were first introduced in Australia on 1 July 2008, so in order to negate the effect of the FiTs introduction, the baseline scenario will begin from January 2008 on a business as usual basis, i.e. with no exogenous stimuli for the installation of RE. Estimates of PV and Wind installations to 2020 are based on pre-FiT installation trends from 2001-2008.

4.2 FiT Scenario

The FiT scenario will use the outcomes of the author's review (2016), and project changes in electricity supply sources within the NEM to 2020 according to the following assumptions:

1. Solar and wind power deployment increases are calculated based on deployment trends to 2014 (Australian PV Institute, 2014, Clean Energy Council, 2012-14, IEA 2010-11, AER, 2009). Generation is determined based on average NEM solar and wind per annum generation levels (Solar: ~1460GWh/GWp, Wind ~2600GWh/GWp).

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2. In order to determine residential Solar PV net FiT payments, electricity export rates are rationalised between 32 and 50% depending on the average annual size of PV systems installed as follows (IPART, 2012):
    a) 1kWp systems export 32% of generated electricity;
    b) 1.5kWp systems export 35% of generated electricity;
    c) 2kWp systems export 41% of generated electricity; and,
    d) 3~5kWp systems export 50% of generated electricity to the grid.
3. FiTs are payable based on the applicable FiT in the state and year of installation, for so long as the FiT is guaranteed[7].
4. It is assumed that FiTs in place in 2015 will continue unchanged to 2020.
5. As FiT households receive a financial benefit from the generation of RE (as a reduced electricity bill), calculation of the FiT burden considers non-FiT households exclusively.

4.3 Alternative Energy Scenario

The alternative energy scenario will use the environmental and economic learnings derived from the baseline and FiT scenarios in order to best achieve policy goals, whilst improving social equity outcomes according to Australian equity preferences according to the following constraints:

Social equity is should be maximised (i.e. through a fairer distribution of costs and benefits of energy policy) subject to:

1. No increase in electricity prices for residential consumers, compared to 2014 levels (as policy settings are only modified from 2015 onwards);
2. RE technology is deployed with maximum practicable efficiency in order to meet RET targets;
3. GHG emissions are reduced to contribute to Australian cumulative (all sector) GHG reduction efforts; and
4. Job creation is maximised subject to 1, 2 and 3, maximising positive GDP impacts.

[7] A summary of FiTs to the end of 2012 is available in Chapman et al, 2016.

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5. Results

5.1 Baseline and FiT Scenario Environmental Outcomes

Using the assumptions outlined in the methodology, electricity generation and GHG forecasts are detailed, encompassing all fossil and RE based electricity sources for the baseline and FiT scenarios from 2008 to 2020 (see Appendix A). The change in fossil fuel based electricity generation levels for each scenario is detailed at Figure 2 and RE based electricity generation levels are detailed in Figure 3.

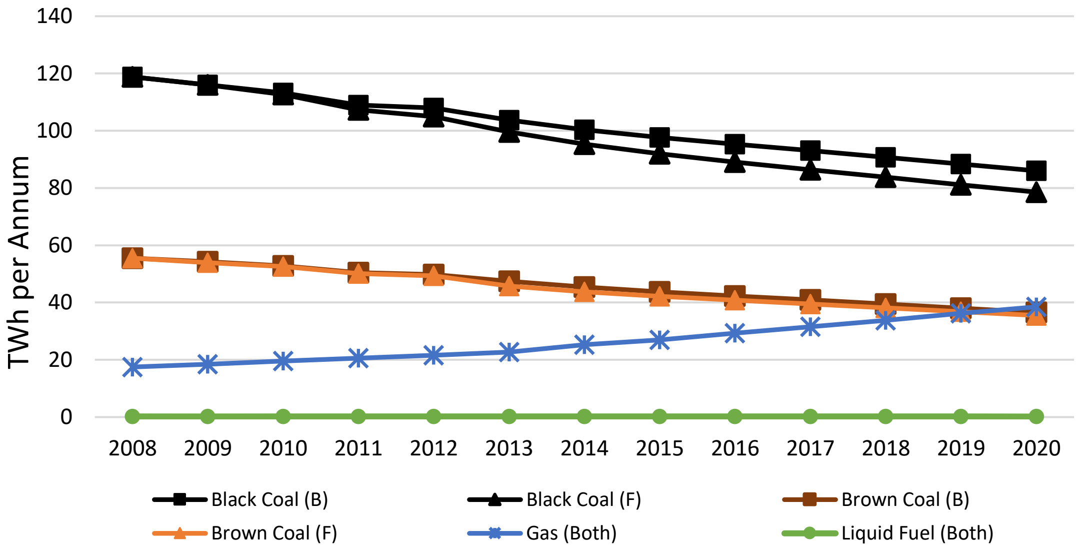

Figure 2. FiT (F) and Baseline (B) Scenario Fossil Fuel Generation Levels 2008-2020

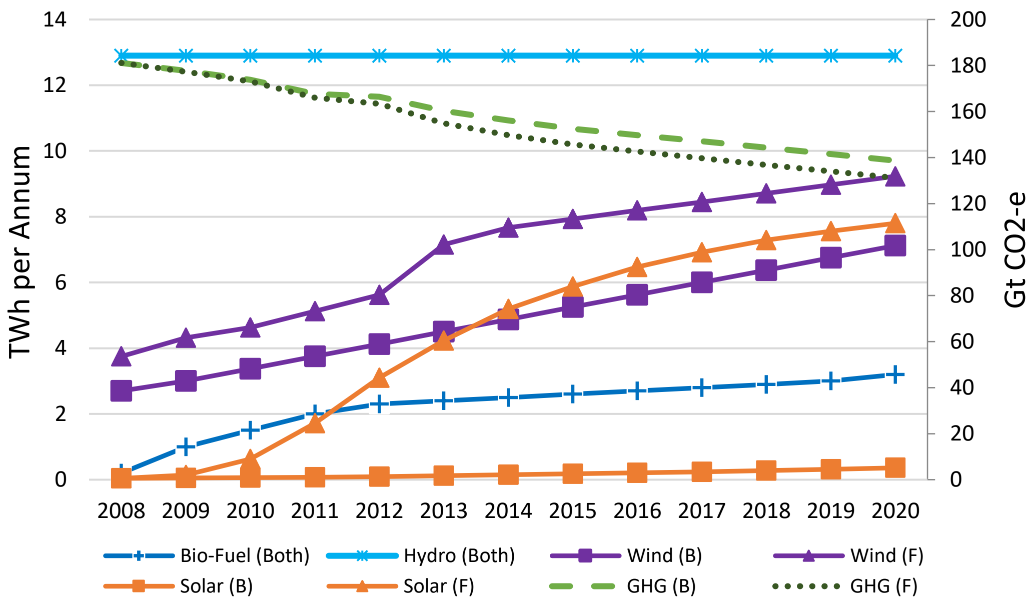

Figure 3. FiT (F) and Baseline (B) Scenario RE Generation Levels 2008-2020

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As shown in Figures 2 and 3, the FiT stimulates significant additional solar based generation, alongside a moderate increase in wind based generation. These increases lead to a moderate decrease in black coal generation, and a minor decrease in brown coal generation. Hydro, bio-fuel and gas based generation are assumed to be the same in both scenarios. The GHG emission decrease for each scenario is also shown.

Under the baseline scenario, the major factors which influenced the reduction in GHG emissions were an increase in gas generation to more than double 2008 levels, a significant increase in wind power generation to account for almost 4% of all generation by 2020, and substantial growth in the biofuel industry. However, the most significant change across the NEM was the steady reduction in gross electricity generation from 2014, allowing for a commensurate reduction in both black and brown coal generation, in addition to that offset by RE based generation in both scenarios.

From an RE deployment point of view, under the baseline scenario, generation from renewable sources grew from a low of 7.6% in 2008, up to 12.8% in 2020. Large scale RE (Hydro, Wind and Bio) accounts for approximately 23,000GWh of total generation within the NEM. Under the FiT scenario, RE generation in 2020 accounts for almost 18% of the NEM's generation, with large scale RE sources supplying approximately 25,000 GWh.

As for RE technology deployment efficiency, the four major types of RE generation technology each have different GHG intensities and energy generating capacities which are used to calculate the overall efficiency of RE deployment within the NEM as follows: Hydro is the most effective from a GHG emission reduction per MWh standpoint, and is maximised under all scenarios. The next most effective is Wind, followed by Bio-fuel (also known as biomass[8]), which is predominantly sourced from bagasse in Australia, with the remainder coming from agriculture and other waste products (CEC, 2014). Further, Wind is superior from an electricity generation standpoint, exceeding both Bio-fuel and Hydro under these scenarios.

A summary of both scenarios' environmental outcomes for the target year of 2020 is outlined in Table 3.

[8] 2010 estimates of Biomass potential in Australia at approximately 40.17 TWh per annum from Bagasse, agricultural and other waste biomass sources (Crawford et al, 2012)

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Table 3. Summary of Baseline and FiT Scenario Environmental Outcomes in 2020

Factor	Baseline Scenario Outcomes	FiT Scenario Outcomes
GHG Emissions	Gross GHG Emission Reduction (%)	
	23.4	**27.6**
	NEM Generation GHG Intensity Reduction (%)	
	13.9	**19.6**
RE deployment	RE Generation in NEM (%)	
	12.8 (63.8% of target)	**17.9 (89.6% of target)**
	Large Scale RE in NEM (GWh)	
	23,220 (56.6% of target)	**25,330 (61.8% of target)**
RE Technology system efficiency	GHG intensity of RE (tCO_{2-e}/MWh)	
	0.011	**0.017**
	Generation Efficiency of RE (MWh/MWp)	
	1791	**2043**

5.2 Baseline and FiT Scenario Economic Outcomes

In order to assess the impact of each scenario on electricity prices, the Levelised Cost of Electricity (LCOE) is used. Calculations are based on average projected LCOE factors across generation sub-types from the Garnaut Climate Change Review (commissioned by Australia's Commonwealth, State and Territory Governments in 2007 and 2010, in order to conduct an independent study of the impacts of climate change on the Australian economy) and Australian Treasury modelling studies data, AEMO data (detailed in ATSE, 2014) and analysis of future OECD generation costs (West, 2012) distributed across the projected sources of generation in the target year of 2020. These are detailed for the FiT and baseline scenarios in Table 4.

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Table 4. Baseline and FiT Scenario LCOE for RE & Fossil Fuel Generation in 2020

	Baseline Scenario		FiT Scenario	
Fuel Source	**2020 TWh**	**LCOE$/MWh**	**2020 TWh**	**LCOE$/MWh**
Black Coal	86.00	$95	78.57	$95
Brown Coal	36.56	$100	35.50	$100
Gas	38.50	$82	38.50	$82
Liquid Fuel	0.18	$160	0.18	$160
Bio-Fuel	3.20	$63	3.20	$63
Hydro	12.90	$83	12.90	$83
Wind	7.12	$92	9.23	$92
Solar PV	0.36	$265	7.80	$265
Total	**184.91**	**$92.12**	**184.91**	**$99.45**

Under the FiT Scenario, there is an impact on electricity prices due to early FiTs exceeding standard electricity tariffs and the nature of FiT payment recuperation by electricity companies, through consumer's electricity bills. In some states, short term Gross FiTs were in place. Gross FiTs caused the greatest upward pressure on electricity prices, as all electricity generated by household PV was rewarded at the generous FiT level. Most states introduced, or switched to net FiTs, which only reward households for electricity exported to the grid, with the balance consumed in the home.

Figure 4 shows the growth of FiT payments to 2020, used to derive the cumulative impact of FiTs on electricity prices, averaged across non-FiT NEM households to 2020.

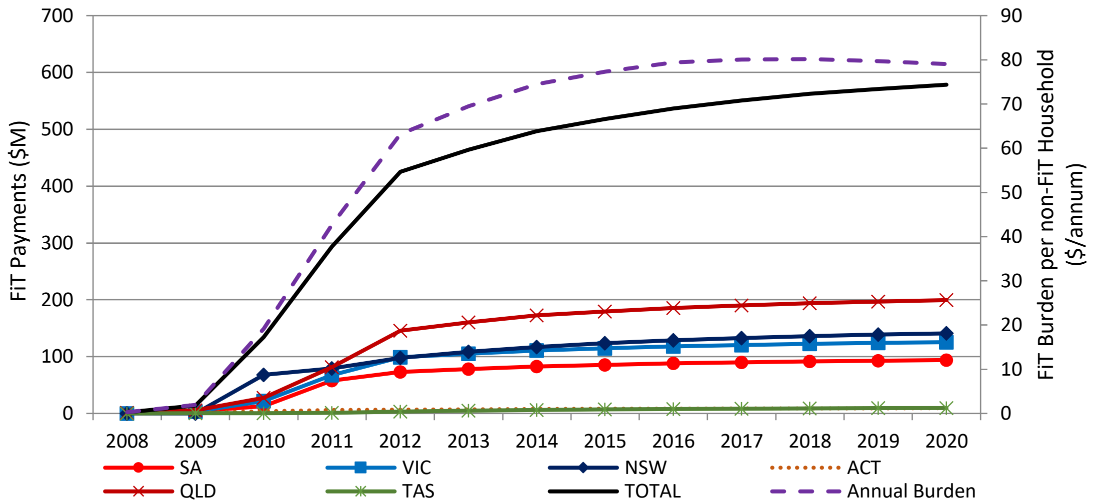

Figure 4. FiT Payments and non-FiT Household Burden in Australia, 2008-2020

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FiT payments increase significantly between 2009 and 2012, and then grow slowly to a peak in 2018, before gradually reducing to approximately $79 per non-FiT household in 2020. It is generally accepted that in Australia, the purchase of solar panels is undertaken by households with sufficient income to do so (Higgins et al, 2014, Bruce et al, 2009), whilst non-FiT households are generally lower income households, non-home owners or those living in apartment style accommodation. This burden of the FiT subsidisation is borne by those with lower means than those who benefit from it. This scheme affects equity through cross subsidisation from low to high income families. Electricity retailers recoup the cost of all FiT payments through electricity bills, irrespective of the nature or size of the FiT, leading to increased electricity bills for non-FiT households, even when the FiT for each kilowatt hour is lower than the gazetted tariff.

The GDP impact of each scenario in this study is described in terms of jobs directly resulting from RE deployment to the target year of 2020. To calculate these jobs established 'job multipliers' (number of jobs per MWp installed) for each technology are used, as detailed in Table 5. Solar PV jobs[9] per MWp are derived from the authors' Australian RE policy review, whilst additional RE technology types' jobs per MWp are derived from national reports and assessments of clean energy installation impacts (SKM, 2012, The Climate Institute, 2011).

Table 5. Job Multipliers for RE Technologies Deployed in Australia 2008-2020

RE Type	Jobs/MWp
Bio-Fuel	2.1
Hydro	*[10]
Wind	2.7
Solar PV	10.8

Market impacts are described in terms of technology learning curve impacts (system price per watt) for the two dominant RE types newly deployed in Australia; described for PV in Figure 5 (derived from APVI, 2014 and Chapman et al, 2016) and for wind

[9] Solar PV jobs are assumed to come from small-scale PV installation (accounting for ~95% of all solar installation in Australia by 2012, Chapman et al, 2016)
[10] *Average actual annual employment figure of 1586 jobs is used (ABS, 2015)

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power in Figure 6 (derived from Junginger et al 2005[11], IEA, 2008 and Melbourne Energy Institute, 2011).

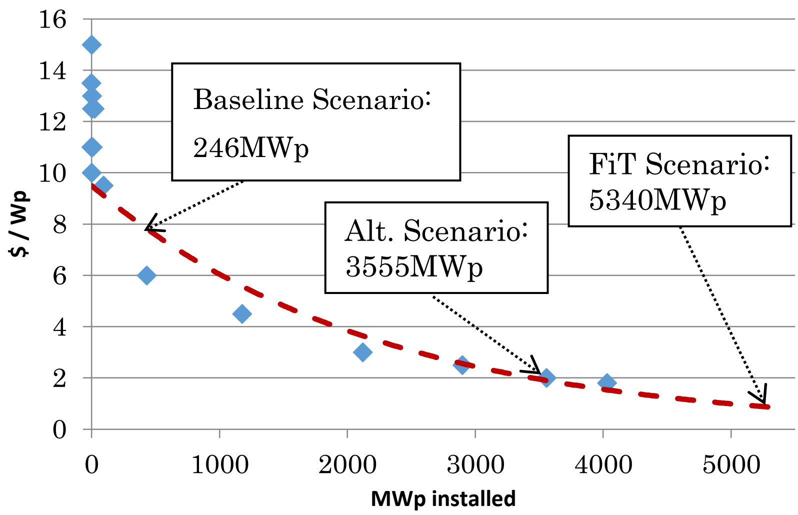

Figure 5. PV Market Impact Learning Curve: Scenario Specific Installation Levels and System Prices per Watt in 2020.

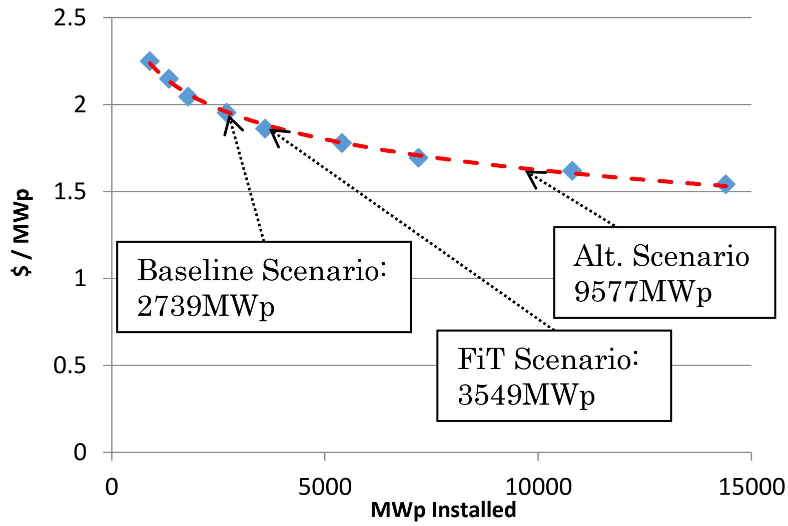

Figure 6. Wind Market Impact Learning Curve: Scenario Specific Installation Levels and System Prices per Watt in 2020.

In order to streamline the results section, the installation totals and system price for the alternative scenario in 2020 is also included in Figures 4 and 5 and is detailed in section 5.3.2.

A summary of economic outcomes for the baseline and FiT scenarios in the year 2020 are detailed in Table 6.

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[11] Using a conservative 9 % cost reduction per doubling of capacity

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Table 6. Summary of Baseline and FiT Scenario Economic Outcomes in 2020

Factor	Baseline Scenario Outcomes	FiT Scenario Outcomes
Cost of Generation	LCOE ($/MWh)	
	92.12	**99.45**
Electricity Price	Impact ($)	
	Non-significant Change	**79.01 per non-FiT NEM household**[12]
GDP Impact	Direct RE Jobs	
	2,432	**3,797**
	Growth from 2008 (%)	
	28	**51**
Market Impact	Solar PV ($/Wp)	
	7	**1**
	Wind ($/Wp)	
	1.96	**1.86**

5.3 Alternative Energy Scenario

Following the vastly different results obtained from the baseline and FiT scenarios, both in terms of effectiveness; the environmental and economic benefits gained or costs incurred, we can begin to appreciate the impact policy settings have on sustainability outcomes within a society. Whilst a wholesale revision of energy policy settings beginning in 2008 would be ideal in order to derive the most sustainable outcomes, one of the limitations of policy implementation is that we are unable to turn back the clock, and can only effect change moving forward, following an evaluation process and the establishment of an evidence base for future action. In order to reduce some inequitable outcomes projected under the current FiT Scenario and additionally to fully meet the environmental goals of the RET, key learnings from both the Baseline and FiT Scenarios must be applied.

From an environmental perspective, it is clear that a significant (>5000MWp) installation of residential PV was insufficient to achieve the RET environmental goals. Additionally, wind power is the most efficient electricity generator, and the second most effective GHG reducing technology (Although Hydro is the most efficacious from a GHG emissions per MWh generation standpoint, it is already maximised in all scenarios).

[12] Using ABS household projection figures, revised to account for NEM and non-FiT household numbers.

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From an economic perspective, solar PV deployment created the most jobs among RE technologies, followed by wind power, but was also the most expensive from an LCOE and electricity price impact point of view due to the FiT. Solar PV is the cheapest technology per watt installed, however wind power's superior electricity generation potential makes it a more economically sound choice than Solar PV. These findings represent the evidence base upon which the alternative energy scenario will be constructed.

Applying these learnings, under the scenario which adheres to the goals and constraints described in section 4.3, a generation and GHG forecast to 2020 is derived (Appendix B), and resultant projected changes in fossil fuel and RE generation sources are summarised in Figures 7 and 8.

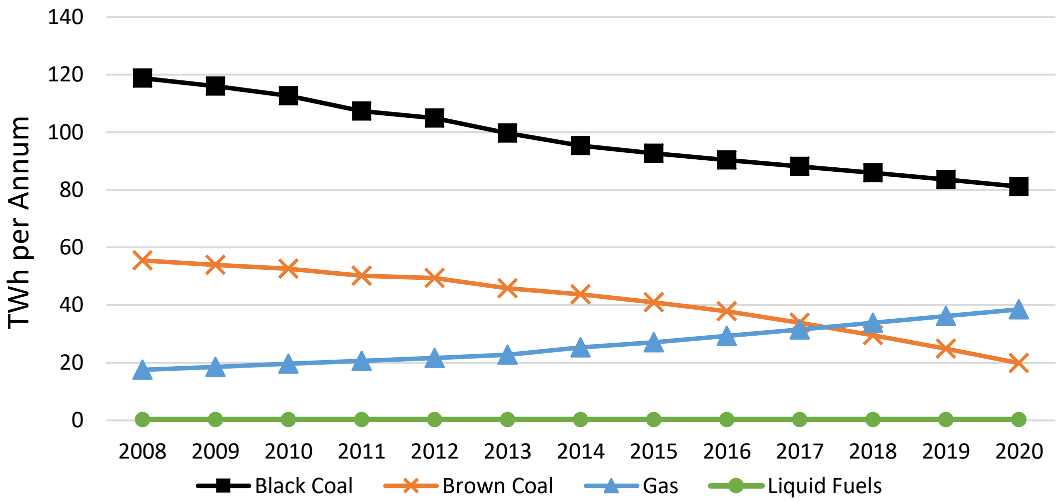

Figure 7. Alternative Energy Scenario Fossil Fuel Generation Levels 2008-2020

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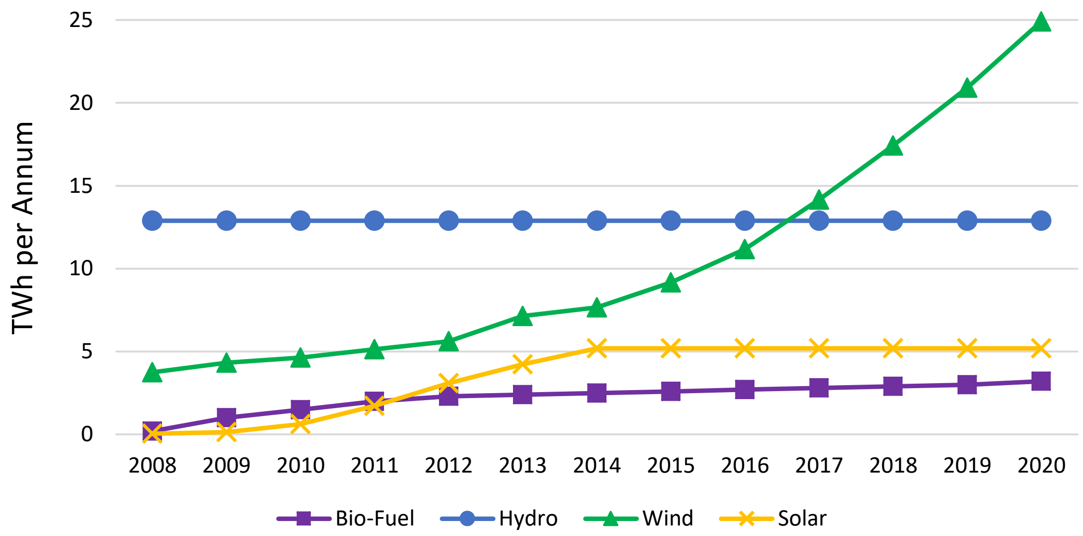

Figure 8. Alternative Energy Scenario RE Generation Levels 2008-2020

Generation and GHG emission outcomes to 2014 are identical to the FiT scenario, as optimisation of the energy system takes place from 2015 onwards. The most obvious difference to the system is the cessation of installation of predominantly residential PV. As wind power is the most effective from both an electricity generation and cost of installation standpoint, it is installed centrally at the large scale in order to meet both the RE installation and large scale RE generation targets. The installation rate is increased significantly each year to 2020 in order to achieve the RET goals whilst recognising the time required for an industry transition from residential solar to large-scale wind.

5.3.1 Alternative Environmental Outcomes

By switching to a centralised, wind based RE generation regime, both the RE installation and generation targets can be met. Additionally, due to intensive wind installation in predominantly southern, brown coal states, GHG emissions are reduced by approximately 67.2Gt, reducing the NEM GHG emission intensity by some 29.3%. A summary of alternative energy scenario environmental outcomes is at Table 7.

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Table 7. Summary of Alternative Scenario Environmental Outcomes in 2020

Factor	**2020 Outcomes**
GHG Emissions	Gross GHG Emission Reduction (%)
	37.10
	NEM Generation GHG Intensity Reduction (%)
	29.30
RE deployment	RE Generation in NEM (%)
	24.98 (Exceeding target)
	Large Scale RE in NEM (GWh)
	41,000 (100% of target)
RE Technology System Efficiency	GHG intensity of RE (tCO_{2-e}/MWh)
	0.013
	Generation Efficiency of RE (MWh/MWp)
	2265

5.3.2 Alternative Economic Outcomes

As with the baseline and FiT scenarios, the alternative scenario LCOE and job numbers are defined according to the makeup and cost of 2020 generation sources and RE job multipliers (previously defined in Tables 4 and 5).

Market impacts as a result of the alternative scenario for PV and Wind were shown in Figures 5 and 6 alongside the Baseline and FiT scenario results, and a summary of economic outcomes for the alternative scenario in the year 2020 are detailed in Table 8.

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Table 8. Summary of Alternative Scenario Economic Outcomes in 2020

Factor	2020 Outcomes
Cost of Generation	LCOE ($/MWh)
	96.36
Electricity Price	Impact ($)
	64.47 per non-FiT NEM household[13]
GDP Impact	Direct RE Jobs
	5,885
	Growth from 2008 (%)
	136
Market Impact	Solar PV ($/Wp)
	2
	Wind ($/Wp)
	1.65

With regards to policy efficacy, the achievement of the two RET goals of total RE installed and large scale RE generation for all three scenarios in the target year of 2020 are compared in Figure 9.

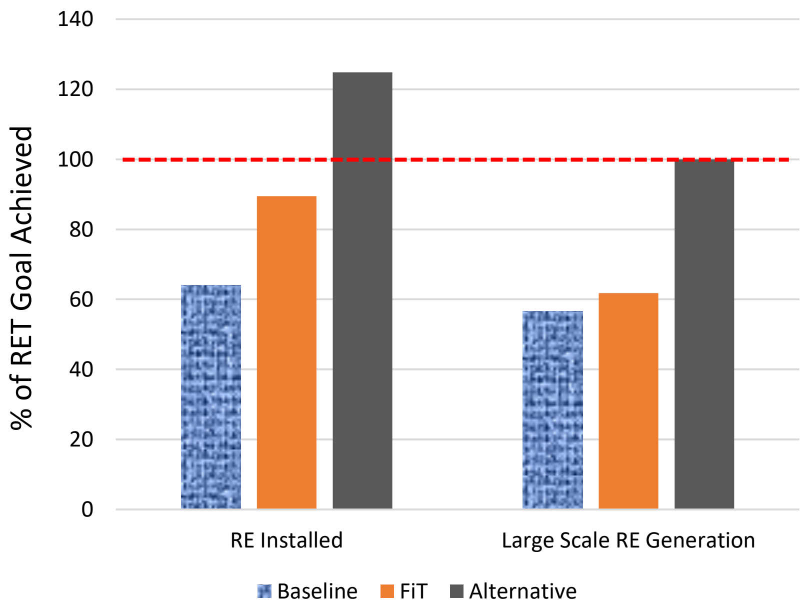

Figure 9. Scenario Specific RET goal efficacy comparison in 2020

[13] Using ABS household projection figures, revised to account for NEM and non-FiT household numbers.

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6. Comparative Efficacy and Equity Assessment

In order to derive a complementary equity assessment for each scenario to the target year of 2020, an evaluation of the distribution of environmental and economic impacts is undertaken across the five levels of low to high incomes in Australian households (defined in Appendix C). These income levels are not described as quintiles, but are the actual percentage of households in each income 'bracket'. In Australia, very low, low and average income households make up 71.25% of all households, the remaining 28.75% of households are high and very high income households, with very high income households accounting for 6.11%.

Each of the three scenarios assessed describes a vastly different energy future for Australia in the year 2020, achieving environmental and economic goals at differing levels. The achievement, and means of achievement impacts upon societal equity as each household is impacted differently according to their level of participation and subsequent allocation of subsidies, the amount and distribution of GHG reductions as well as policy driven electricity price and employment impacts (the energy policy equity impacts specific to Australia, as identified in section 3.1).

In order to understand the relative equity level and societal burden imparted by each scenario, the distribution of these economic and environmental costs and benefits is determined, and their impact weighted according to the comparative size of each of the impacts assessed, across the 3 energy scenarios, for the 5 income levels. Table 9 outlines the precedents and assumptions used for these distributions and their weighting.

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Table 9. Australian equity distribution and weighting factors

Equity Factor	Distribution Factors	Weighting Factors
Participation	Australian participation precedents (Higgins et al, 2014, Bruce et al, 2009)	% of non-subsidized households
GHG Reduction	Assumed to be equal	Gt of GHG reduced
Employment	Australian review job allocation and salaries (Payscale, 2015)	Number of direct RE Jobs in 2020
Subsidy Allocation	Participation rate multiplied by % of households per income level	Subsidy (FiT) payment amount
Elec. price impact	Elec. price % increase due to subsidization (or LCOE increase) per income level	Actual $ increase per annual average electricity bill

A matrix of the distribution factors, based on precedents and calculations as outlined in Table 9 is initially populated for each scenario for each of the scenario years 2008-2020. These distribution factors are then rationalized according to the ratio of the absolute values of the weighting factors (to a maximum value of 1), simultaneously across all 3 scenarios in order to derive the relative equity for each income level. This concurrent comparative analysis identifies the relative cost and benefit distribution bias and relative equity simultaneously for each of the 3 scenarios based on the difference in distribution of economic and environmental impacts, between the highest and lowest income levels. The equity and societal burden assessment takes an equally weighted assessment of each of the 5 equity factors across the 5 income levels, and based on these values plots a centroid for each scenario from 2008-2020, in order to enable an objective comparison of equity level and societal burden outcomes over time. Salient formulae for determining these values are outlined below.

Firstly, for equity factors across each income level:

$$EF\ for\ income\ level_{(very\ low \dots very\ high)} = DF_{(1 \dots n)} * \frac{WF_{(1 \dots n)}}{MaxWF_{(1 \dots n)}}$$

Where EF, DF and WF are the equity, distribution and weighting factors respectively, and n is the number of factors. Using the five derived equity factor values for each income level, relative equity can be established thus:

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$$Relative\ Equity\ for\ income\ level_{(very\ low \ldots very\ high)} = EF_{(1 \ldots n)/n}$$

The distribution bias (DB) is then determined by the difference between the highest income levels relative equity and the lowest for each equity factor assessed.

$$DB = EF_{(very\ high\ income)} - EF_{(very\ low\ income)}$$

6.1 Results of the Comparative Efficacy and Equity Analysis

Firstly, per scenario relative equity results (with centroids shown) for the year 2020 are displayed in Figure 10 for each of the 5 income levels.

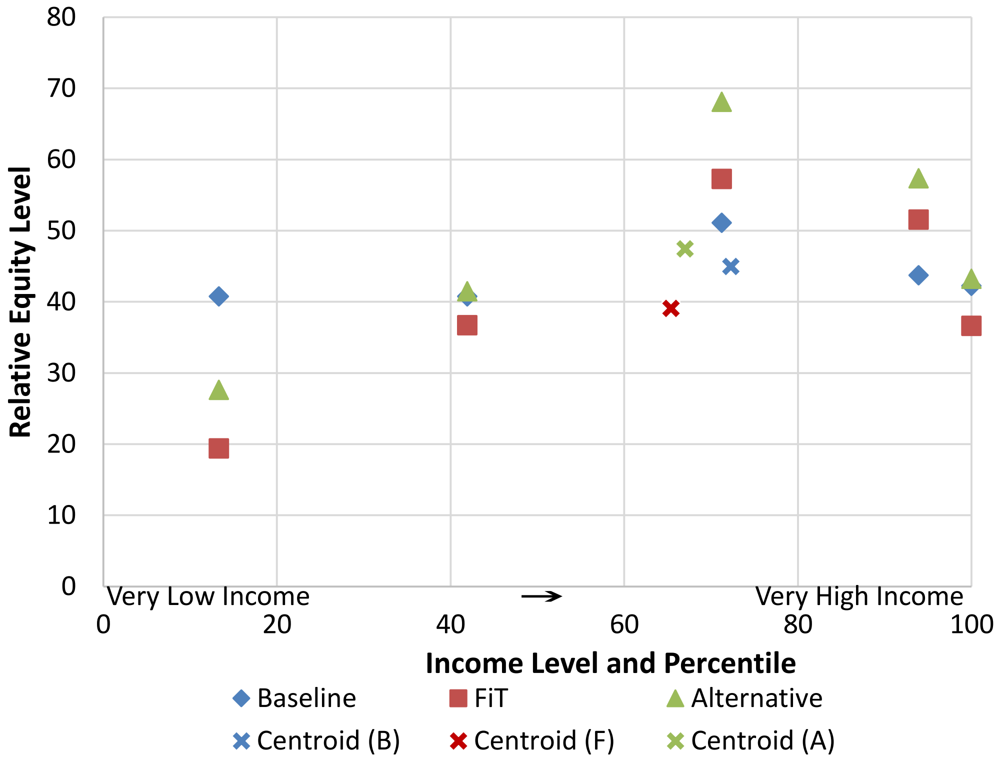

Figure 10 Per Scenario Relative Equity Levels in 2020

In 2020, the Baseline scenarios relative equity level is fairly even across the 5 income levels, demonstrated by a very small difference between the lowest, average and highest income levels, indicating relatively balanced societal equity. The FiT scenario has the lowest relative equity for the very low income group. Additionally, the FiT scenario difference between lowest and highest income levels is the greatest overall. Comparatively, the alternative scenario has a higher overall relative equity level for all income groups, and a smaller difference between the lowest and highest income levels.

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These differences affect the overall relative equity which is represented by the relative equity centroid, shown as a color-coded 'X' for each scenario. The higher the centroid is on the Y-axis, the greater the overall relative equity for each scenario. The further to the left the centroid is on the X-axis, the greater the burden on lower income households.

Secondly, the distribution bias resultant from each scenario in the target year of 2020 is shown in Figure 11, for each of the 5 equity factors.

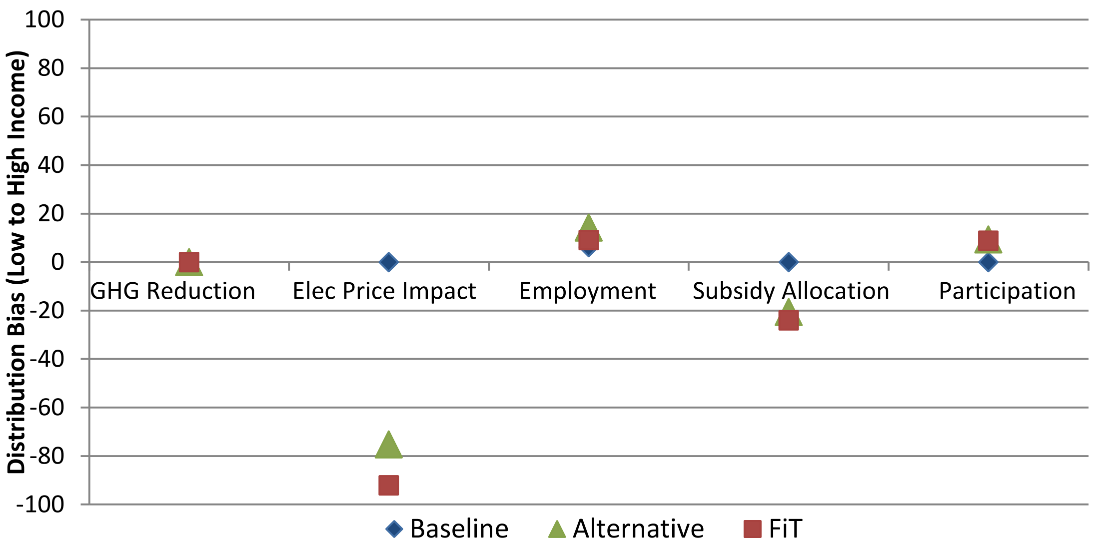

Figure 11. Per Scenario Equity Factor Distribution Bias in 2020

In this study, greenhouse gas reductions are assumed to be equal across all households, and therefore for each scenario there is no distribution bias. With regard to electricity price impacts, the baseline scenario introduces no subsidised electricity generation and therefore no bias is experienced. In the case of the FiT scenario, the increase in electricity bills due to FiT payments impacts lower income households significantly. This is lessened under the alternative scenario. Employment outcomes favour higher income households in each scenario, due to the nature of jobs created. With regard to subsidy allocations, under the baseline scenario, no allocations are made, and therefore no bias is experienced, however under the FiT scenario, lower income households are seen to be cross-subsidising higher households. As with the electricity price impacts, this situation is somewhat remedied under the alternative scenario. With regard to participation, the baseline scenario sees even participation for all users due to a centralised electricity system. With the introduction of the FiT, lower income households are less able to participate exacerbating the bias in favour of higher income households. Due to the increase of centralised RE installation and a cessation of

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residential PV installations from 2015, this bias is reduced slightly under the alternative scenario.

Finally, in order to observe how the level of equity and the impost of societal burden as a result of the policy settings in each energy scenario changes over time, the equity level and societal burden centroids (shown and discussed for the target year of 2020 in Figure 9) from 2008-2020 are plotted, as shown in Figure 12 in order to demonstrate how equity and societal burden shift over time.

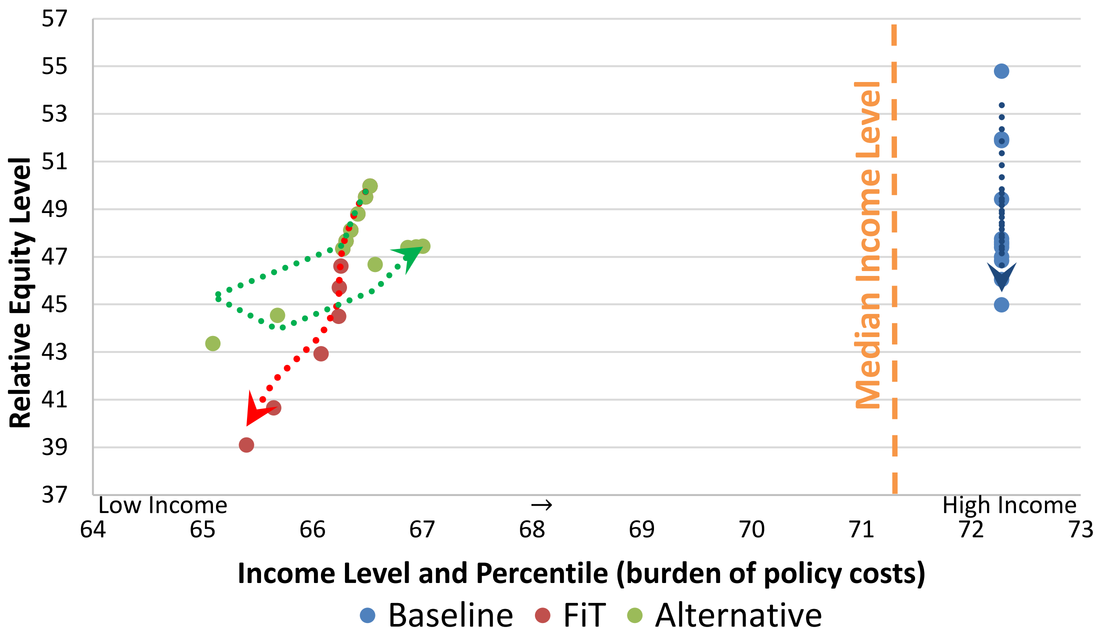

Figure 12 Scenario Specific Relative Equity and Societal Burden 2008-2020

As was the case with Figure 10, in Figure 12 equity improvement is shown by a shift upwards on the Y axis and the X axis shows the shifting of the societal burden of policy costs, where a shift to the right over time is desirable. The FiT and alternative scenarios are identical from 2008-2014 and do not separate until the year 2015, the FiT scenario gradually reduces in relative equity and the burden of policy costs shift toward low income households. The alternative scenario is increasing its level of relative equity over time when compared to the other scenarios and the burden of policy costs is shifting towards the median income level. The baseline scenario's burden of policy costs is borne by average to high income households and over time, due to little economic or environmental policy achievement when compared to other scenarios, relative equity reduces.

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7. Discussion

This paper has focused on the incorporation of a quantitative assessment of equity within policy evaluation. Equity is a key component of distributive energy justice, and should contribute to new policy initiatives (Johnston et al, 2014).

The contribution of this paper toward policy initiatives and policy making is threefold: Firstly, a realistic evaluation of a policies ultimate success with regard to environmental and economic goals can be made, in addition to gaining an understanding of the potential distributive equity impacts that such a policy approach may engender.

Secondly, through a consideration of both efficacy (the ability of a policy to meet desired goals) and equity impacts, the policy maker can proactively evaluate potential policy pitfalls, and realign policy parameters in order to better meet both efficacy and equity goals.

Thirdly, the evaluation framework proposed allows the policy maker to identify trade-offs inherent in RE policy; i.e. the efficacy cost of giving precedence to societal equity or efficacy, and the identification of a merit order of technologies for each environmental and economic criteria, (summarised in Appendix D) discussed in detail below.

Through this study, the negative impacts of the FiT were identified as unequal participation leading to cross subsidisation; low income households' paying a premium to offset higher income households' FiT payments, and issues at the administrative level, such as the recuperation method of FiT payments by electricity companies, further exacerbating electricity price increases and affordability issues for lower income households. The proposed alternative energy scenario seeks to redress these issues as a priority by incorporating key learnings from both the FiT and baseline scenarios. One of the key learnings described in the alternative scenario is the increased use of wind power, installed centrally, as opposed to continued installation of subsidised rooftop PV. The benefits of wind power were clarified as; superior GHG reduction, as the majority of the Australian wind resource is in brown coal states, and, centralised installation of wind power increases participation rates and reduces the electricity price burden on lower-income households, as no FiT is payable, and by 2020 wind power's LCOE is lower than that of both black and brown coal, and significantly lower than that of residential PV.

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Building upon learnings evident in the Baseline and FiT scenarios, the alternative energy scenario was able to be developed in order to meet both the RE deployment and large scale RE generation targets, and subsequently able to offset the greatest amount of GHG. This was due to pragmatic installation of centralised wind generation which offers the greatest electricity generation and GHG reduction per MW installed in Australia. Additionally, the evidence based alternative energy scenario generated the greatest number of direct RE jobs by 2020, and was successful in moderately reducing the FiT impact and LCOE whilst meeting all RET targets. The baseline scenario had the lowest LCOE and nil FiT impact, but was also the most environmentally ineffective, and did little to stimulate RE jobs or reduce RE technology market prices. Whilst the FiT scenario offers the greatest reduction in installed solar PV prices, it also engenders a significant electricity bill increase due to the FiT, and has the highest scenario LCOE.

Energy justice provides a new direction for research and application in energy policy formulation (Heffron et al, 2015) This is demonstrated within in this study through an assessment of environmental and economic impacts of energy policy scenarios, and the application of this assessment to an understanding of the resultant equity impacts on society. Utilising these assessment outcomes, the policy maker can revise policy parameters, specifically the tools in place to achieve policy goals and implement a new policy in order to meet these goals in a more effective and equitable manner. The evidence based alternative energy policy described in this paper is demonstrative of this process.

Although the level of importance of the equity factors within the proposed efficacy and equity assessment tool may vary according to national preferences or goals (in the case of Australia, outlined in section 3.2), the tool proposed can be adapted according to these preferences or weightings. For this to occur in a proactive manner there is a necessity for a revision of the policy making process, called the policy cycle in Australia (Althaus et al, 2012), in order that evaluation of the sustainability of policy performance is undertaken proactively (prior to implementation), rather than retroactively, as is currently the case. This body of work is a logical next step to this study and would seek to specifically address the issues of procedural justice, and justice as recognition, alongside distributive justice in engendering a policy cycle which includes all stakeholders meaningfully in the development and policy tool design phases in such a way that societal equity can be brought to the fore in energy policy development.

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This study has shown that in Australia the improvement of equity has not been indicative of a decrease in efficacy, as clearly evidenced by the alternative energy scenario which meets environmental and economic goals to a higher level than the FiT scenario whilst offering a modest improvement in equity – practically demonstrating the value of equity incorporation through an evidence based policy development process, in terms of improved energy policy sustainability outcomes and the achievement of environmental and economic goals.

8. Conclusion

The performance of policy with regards to sustainability is a combination of environmental, economic and social contributions. Of the social contributions, equity to date has not typically been included in policy performance assessments. However, this paper demonstrates that essential factors of equity within a jurisdiction can be identified through an assessment of policy evaluation outcomes (as described in section 3.1) and then quantified, through a distribution of the economic and environmental factors which impact upon them, weighted and distributed across societal income levels (detailed in Section 6). By contrasting differing policy scenarios' efficacy and resultant equity impacts, holistic policy sustainability can be demonstrated in an easy to understand manner, and provide a basis for the improvement of policy development processes.

Australia is a prime candidate for such an improvement, as household income levels show, equity impacts which negatively affect average or below income levels are indeed impacting on almost three quarters of Australian society. Other OECD nations with high levels of income inequality (expressed as a GINI coefficient), and who share a similar governance structure to Australia which may benefit from the use of this framework and assessment tool include, but are not limited to: The United Kingdom, Canada, New Zealand and Japan (OECD, 2016).

The approach outlined in this study can be readily applied in other jurisdictions, most likely those identified as having high levels of income inequality within the OECD, and more broadly; through the collection and analysis of jurisdiction specific equity issue and preference information, energy policy tools, goals and energy system data and their application to the framework at Figure 1 and methodology outlined in sections 4 and 6. Needless to say, some assumptions will need to be modified to reflect jurisdictional

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characteristics. However, reflecting on Bickerstaff et al's ideal that there is no single technical fix for energy injustice (2013), but through a holistic social, policy, economic and environmental approach as undertaken in this study, the problems of energy injustice may begin to be remedied. Indeed the sustainability of energy policy can be improved, not only in terms of the environment and the economy but also from a social perspective.

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10. Appendices

10.1 Appendix A

Baseline Scenario Generation and GHG Forecast

Year	NEM Generation (TWh)	Black Coal	Brown Coal	Gas	Liquid Fuels	Bio-Fuel	Hydro	Wind	Solar	Gt CO_{2-e}	tCO_{2-e}/ MWh
2008	207.90	118.80	55.50	17.50	0.20	0.20	12.90	2.70	0.04	181.11	0.87
2009	206.00	116.05	54.24	18.50	0.21	1.00	12.90	3.00	0.05	177.63	0.86
2010	203.70	113.26	52.75	19.60	0.20	1.50	12.90	3.37	0.06	173.85	0.85
2011	199.00	108.92	50.49	20.60	0.20	2.00	12.90	3.75	0.07	167.74	0.84
2012	199.00	107.93	49.79	21.60	0.20	2.30	12.90	4.12	0.09	166.46	0.84
2013	194.00	103.72	47.40	22.70	0.19	2.40	12.90	4.50	0.12	160.32	0.83
2014	191.80	100.37	45.44	25.30	0.19	2.50	12.90	4.87	0.15	156.16	0.81
2015	189.60	97.63	43.78	27.00	0.19	2.60	12.90	5.25	0.18	152.49	0.80
2016	188.65	95.32	42.33	29.30	0.19	2.70	12.90	5.62	0.21	149.74	0.79
2017	187.71	93.09	40.92	31.50	0.19	2.80	12.90	6.00	0.24	147.04	0.78
2018	186.77	90.78	39.48	33.80	0.19	2.90	12.90	6.37	0.28	144.30	0.77
2019	185.84	88.40	38.00	36.20	0.19	3.00	12.90	6.75	0.32	141.50	0.76
2020	184.91	86.00	36.56	38.50	0.18	3.20	12.90	7.12	0.36	138.67	0.75

FiT Scenario Generation and GHG Forecast

Year	NEM Generation (TWh)	Black Coal	Brown Coal	Gas	Liquid Fuels	Bio-Fuel	Hydro	Wind	Solar	Gt CO_{2-e}	tCO_{2-e}/ MWh
2008	207.90	118.80	55.50	17.50	0.20	0.20	12.90	3.75	0.04	181.12	0.87
2009	206.00	115.96	53.97	18.50	0.21	1.00	12.90	4.32	0.14	177.22	0.86
2010	203.70	112.69	52.54	19.60	0.20	1.50	12.90	4.63	0.63	173.13	0.85
2011	199.00	107.28	50.16	20.60	0.20	2.00	12.90	5.13	1.72	165.96	0.83
2012	199.00	104.93	49.34	21.60	0.20	2.30	12.90	5.62	3.10	163.42	0.82
2013	194.00	99.61	45.80	22.70	0.19	2.40	12.90	7.15	4.23	154.91	0.80
2014	191.80	95.33	43.69	25.30	0.19	2.50	12.90	7.67	5.19	149.80	0.78
2015	189.60	91.93	42.15	27.00	0.19	2.60	12.90	7.93	5.88	145.71	0.77
2016	188.65	89.07	40.81	29.30	0.19	2.70	12.90	8.19	6.47	142.64	0.76
2017	187.71	86.41	39.52	31.50	0.19	2.80	12.90	8.45	6.92	139.74	0.74
2018	186.77	83.77	38.19	33.80	0.19	2.90	12.90	8.71	7.29	136.86	0.73
2019	185.84	81.16	36.83	36.20	0.19	3.00	12.90	8.97	7.56	134.01	0.72
2020	184.91	78.57	35.50	38.50	0.18	3.20	12.90	9.23	7.80	131.16	0.71

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10.2 Appendix B

Alternative Energy Scenario Generation and GHG Forecast

Year	NEM Generation (TWh)	Black Coal	Brown Coal	Gas	Liquid Fuels	Bio-Fuel	Hydro	Wind	Solar	Gt CO_{2-e}	tCO_{2-e}/ MWh
2008	207.90	118.80	55.50	17.50	0.20	0.20	12.90	3.75	0.04	181.12	0.87
2009	206.00	115.96	53.97	18.50	0.21	1.00	12.90	4.32	0.14	177.22	0.86
2010	203.70	112.69	52.54	19.60	0.20	1.50	12.90	4.63	0.63	173.13	0.85
2011	199.00	107.28	50.16	20.60	0.20	2.00	12.90	5.13	1.72	165.96	0.83
2012	199.00	104.93	49.34	21.60	0.20	2.30	12.90	5.62	3.10	163.42	0.82
2013	194.00	99.61	45.80	22.70	0.19	2.40	12.90	7.15	4.23	154.91	0.80
2014	191.80	95.33	43.69	25.30	0.19	2.50	12.90	7.67	5.19	149.80	0.78
2015	189.60	92.62	40.90	27.00	0.19	2.60	12.90	9.17	5.19	144.75	0.76
2016	188.65	90.35	37.83	29.30	0.19	2.70	12.90	11.17	5.19	140.01	0.74
2017	187.71	88.14	33.79	31.50	0.19	2.80	12.90	14.17	5.19	134.08	0.71
2018	186.77	85.87	29.47	33.80	0.19	2.90	12.90	17.42	5.19	127.80	0.68
2019	185.84	83.54	24.87	36.20	0.19	3.00	12.90	20.92	5.19	121.16	0.65
2020	184.91	81.17	19.83	38.50	0.18	3.20	12.90	24.90	5.19	113.89	0.62

10.3 Appendix C

Levels and Share of Australian Household Income (ABS, 2014)

Income level	Household income	% of households
Very Low	\$0~\$399 / week	13.31
Low	\$400~\$999 / week	28.62
Average	\$1000~\$1999 / week	29.32
High	\$2000~\$3499 / week	22.64
Very High	\$3500~\$5000+ / week	6.11

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10.4 Appendix D

Economic and Environmental Impact Merit Ordering

Environmental Factors	**Economic Factors**
GHG Reducing Ability **($tCO_{2\text{-}e}$ abated/MWh – higher is better)**	**LCOE** **($/MWh – lower is better)**
1. Hydropower 2. Wind 3. Bio-Fuel 4. Solar PV	1. Solar PV 2. Wind 3. Hydropower 4. Bio-Fuel
RE deployment **(%RE in system)**	**Electricity Price Impact** **(Δ Electricity Price – lower is better)**
Scenario specific.	1. Solar PV 2. Wind 3. Hydropower 4. Bio-Fuel
RE technology system efficiency **(MWh/MWp – higher is better)**	**Jobs Created** **(jobs/MWp – higher is better)**
1. Wind 2. Bio-fuel 3. Hydropower 4. Solar PV	1. Solar PV 2. Wind 3. Bio-fuel 4. Hydro
	Market Impacts **(reduction in RE deployment cost)**
	Scenario specific.